North American Soil Geochemical Landscapes Project

Goals

- Establish baseline geochemistry & microbiology for North America
- Interpret data in light of natural and human factors
  - Geology & climate
  - Industrialization, urbanization & agriculture
- Data for use by environmental agencies and others – baseline risk assessment
- Establish archive of soil samples for future studies
- Identify areas for additional sampling

Timeline

- Initiated by US, Canadian and Mexican, Geological Surveys – 2001
- Additional planning with EPA, other government agencies, universities
- Pilot Studies 2004
- Sampling started 2007
- 10+ years for completion

Previous Studies

- ► Highways
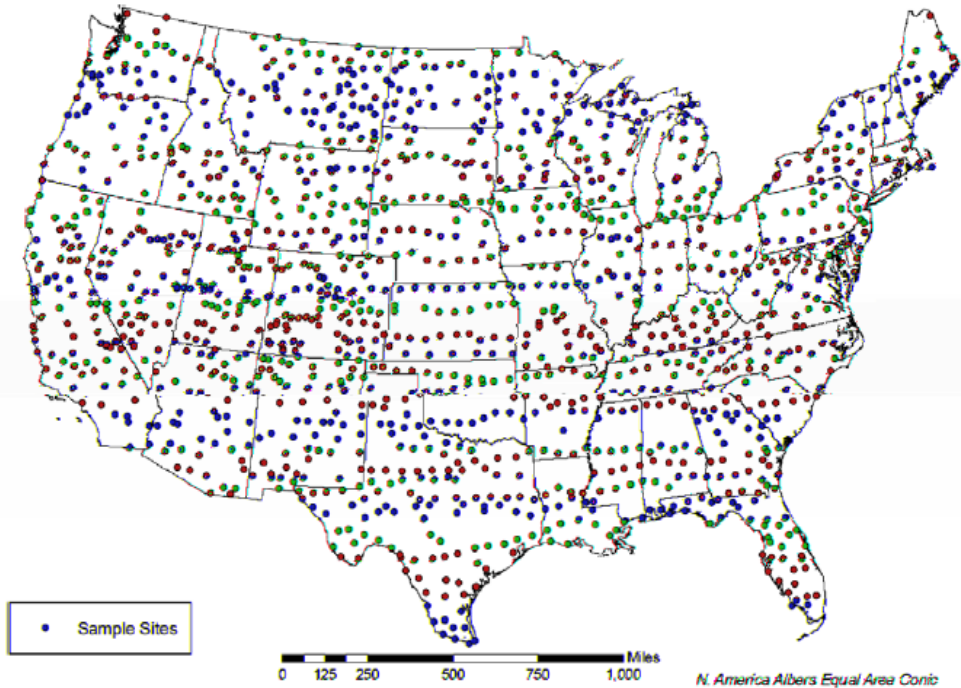- ► Shallow depth (20 cm)
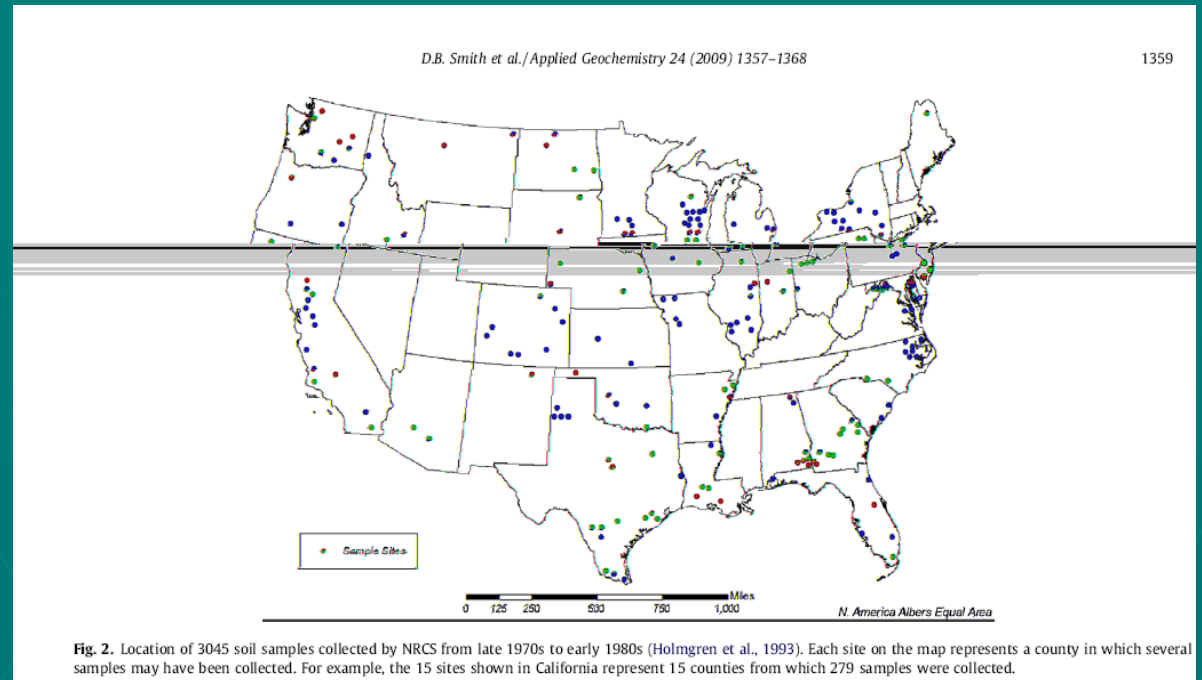- ► Native vegetation

Fig. 1. Location of 1323 soil samples collected by USGS from mid 1960s to late 1970s (Shacklette and Boerngen, 1984).

Previous Studies

- ➤ Natural Resources Conservation Service (1993) – metals in agricultural soils
- ➤ State surveys – different methods

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Sample Sites

Miles
0   125   250   500   750   1,000

N. America Albers Equal Area

Fig. 2. Location of 3045 soil samples collected by NRCS from late 1970s to early 1980s (Holmgren et al., 1993). Each site on the map represents a county in which several samples may have been collected. For example, the 15 sites shown in California represent 15 counties from which 279 samples were collected.
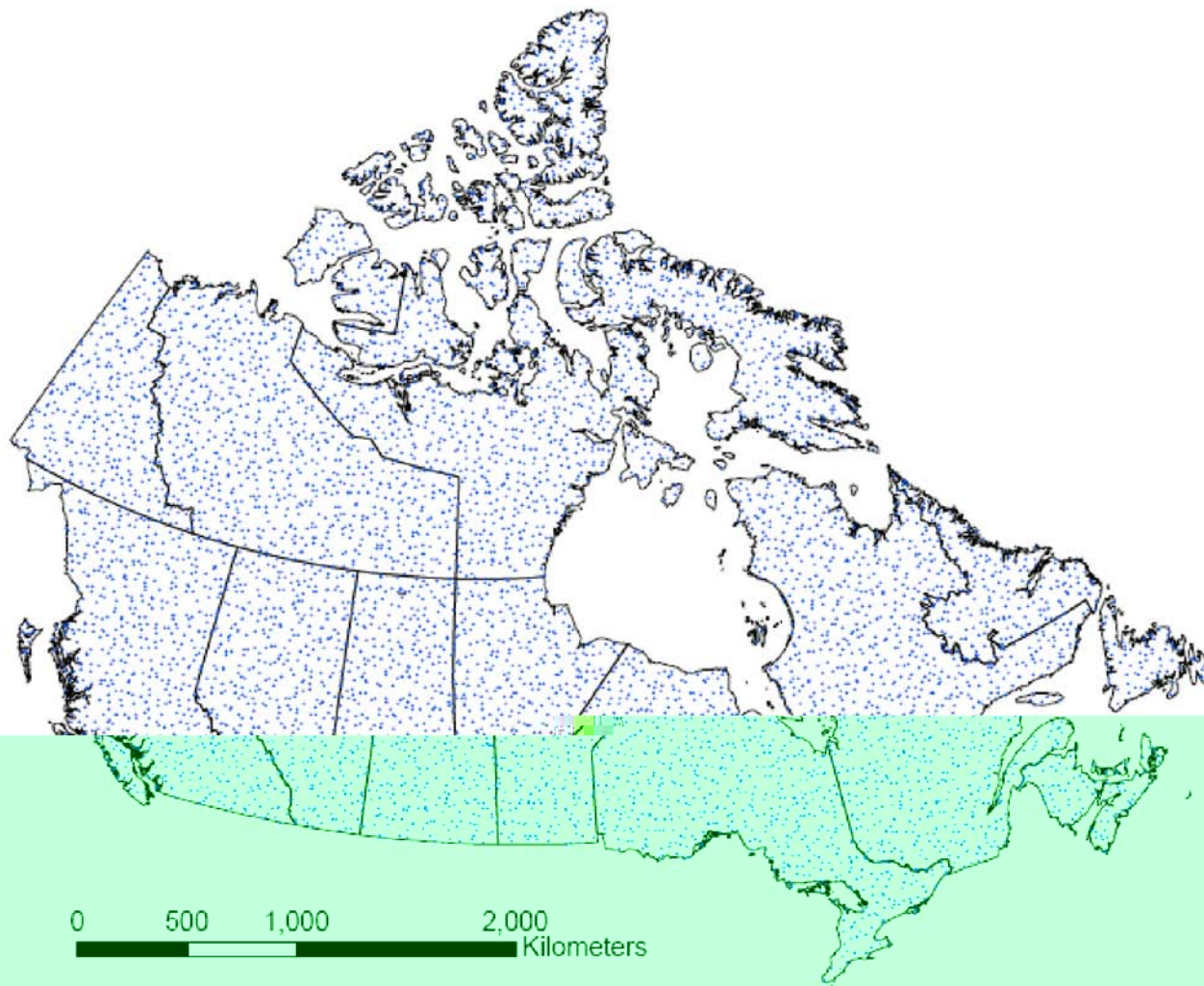
GRTS

- General Randomized Tessellation Stratified sampling design
- Ensures spatial uniformity and randomness unlike previous studies
- 13,596 sites for North America
  - US=5,813   Canada=6,183   Mexico=1,600
- Over 4 times as many sites as Shacklette studies

Sample Locations

USGS
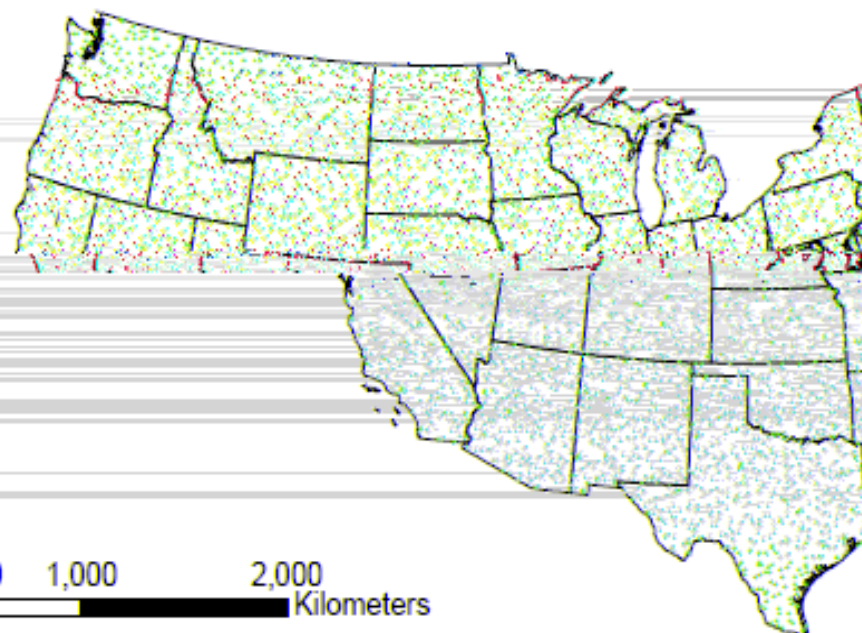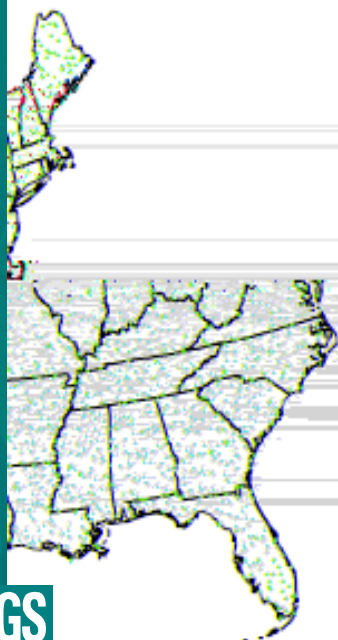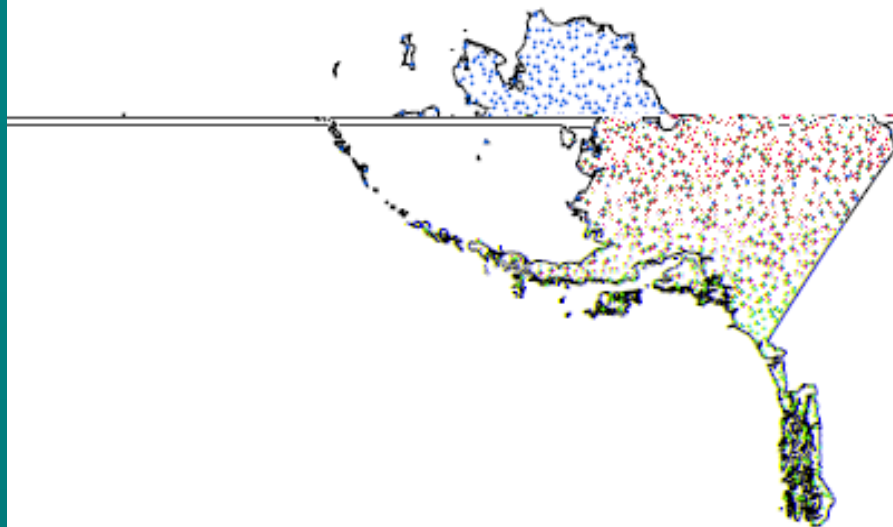
0   500   1,000   2,000
                        Kilometers

Canada

Mexico

Site Selection

- 1 km^2 area centered on GRTS coordinate
- Select site "most representative" of soil and landscape characteristics
- Avoid sites
  - <200m from major highways
  - <50m from rural roads
  - <100 m from buildings
  - End rows of agricultural fields
  - Major industrial emitters – power plants, smelters

Site Selection

Sample Analysis

- Near-total extraction for ~44 major and trace elements (ICP-MS/ICP-AES/AA)
  - Pb, As, Hg, Se
- Total carbon, carbonate carbon (organic carbon by difference)
- *Bacillus anthracis* (anthrax) and other soil pathogens (EPA funding)
- Quantitative mineralogy by X-ray diffraction
- Phospholipid fatty acid (PLFA) analysis on 10% of samples

≋USGS

Microbiology

- Phospholipid fatty acids (PLFA)
  - Can be used to identify microbial/bacterial communities
  - indicator of environmental impact & stress – pollution, metals, temperature
- Soil Pathogens (Anthrax)
  - Determine areas of elevated risk to humans, livestock and wildlife

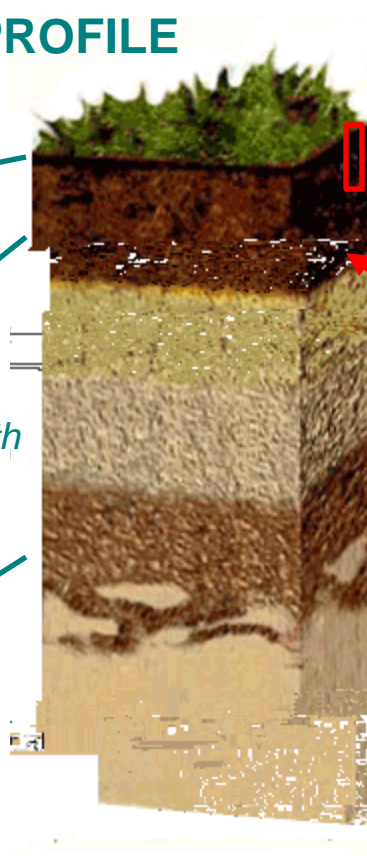# Samples collected from each site

TYPICAL SOIL PROFILE

O horizon
decayed organic matter

A horizon
mineral soil mixed with some organic matter

C horizon
partly altered parent material

1: **0 to 5 cm depth** – regardless of horizon (1 – 2 kg + 1 fifty ml tube for soil pathogens)

2: A horizon (2 kg)

3: C horizon or closest approximation (1 – 2 kg)

USGS

Additional samples from every tenth site
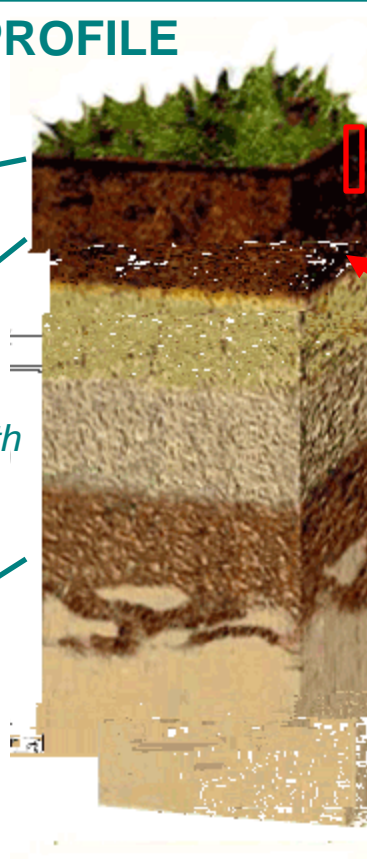

TYPICAL SOIL PROFILE

O horizon
decayed organic matter

A horizon
mineral soil mixed with some organic matter

C horizon
partly altered parent material

1: 0 to 5 cm depth – (1 centrifuge tube for PLFA analysis)

2: A horizon (1 centrifuge tube for PLFA analysis)

3: C horizon or closest approximation (1 centrifuge tube for PLFA analysis)

*Must be kept cold from time of collection.

4: Soil density from A & C horizons

USGS

Pilot Studies

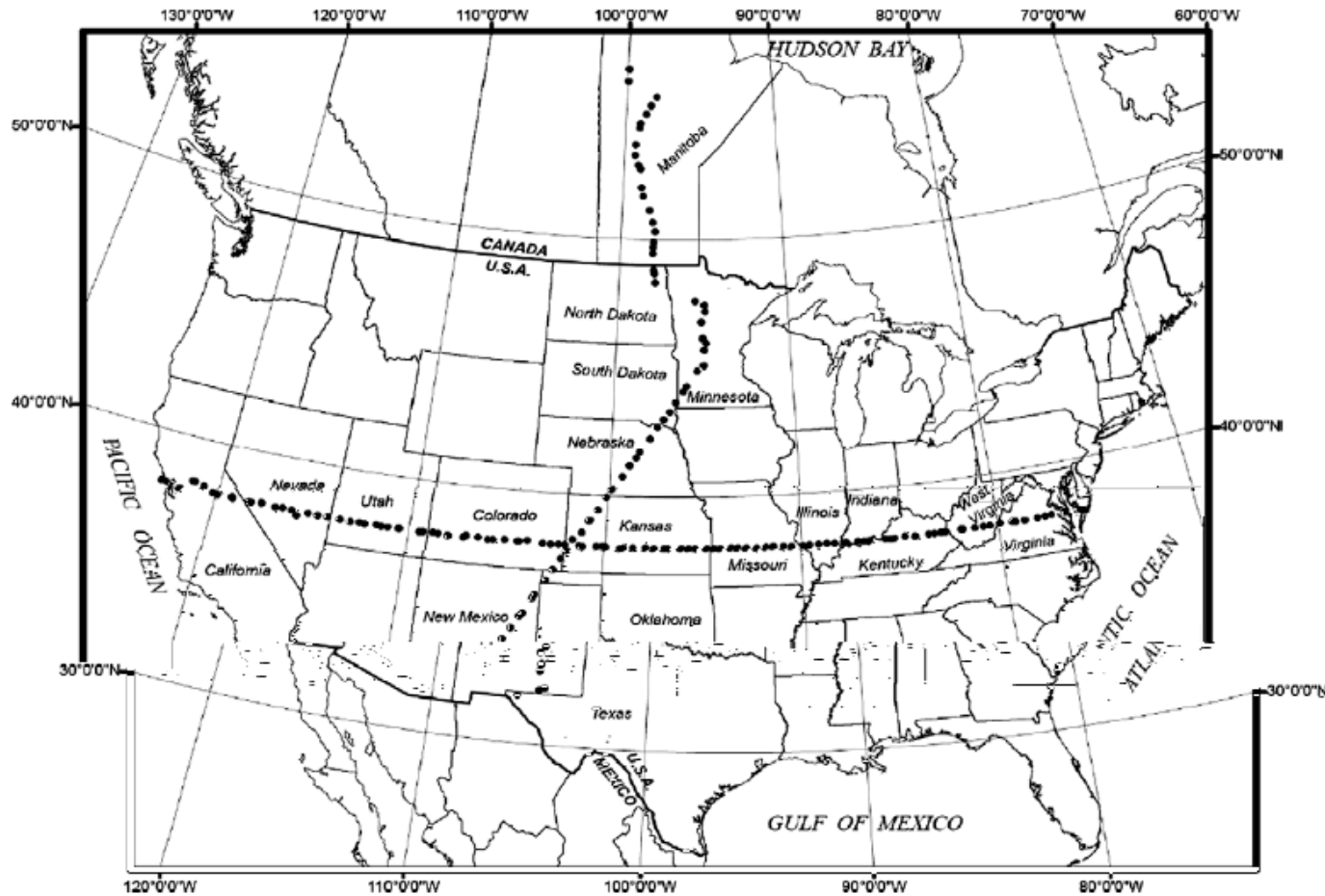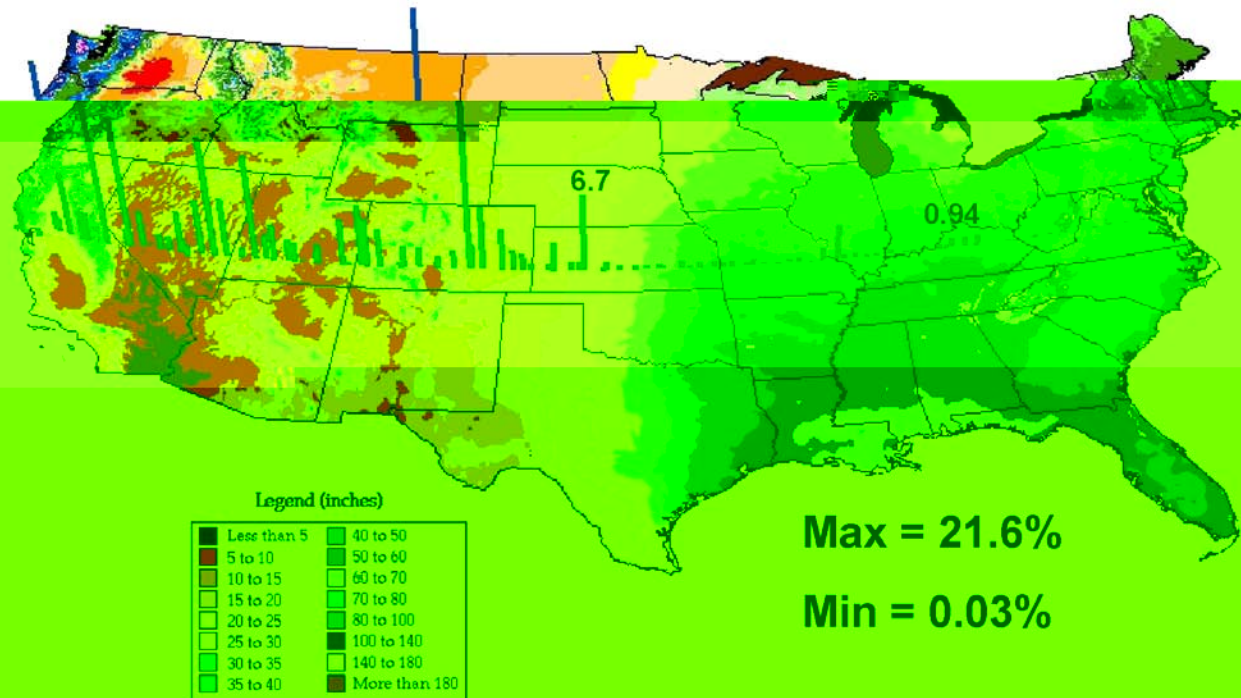D.B. Smith et al. / Applied Geochemistry 24 (2009) 1357–1368

Fig. 3. Location of soil sampling sites along the two transects across Canada and the US.

Pilot Studies

Calcium in A-horizon soils

Max = 21.6%

Min = 0.03%

Legend (inches)

Less than 5	40 to 50
5 to 10	50 to 60
10 to 15	60 to 70
15 to 20	70 to 80
20 to 25	80 to 100
25 to 30	100 to 140
30 to 35	140 to 180
35 to 40	More than 180

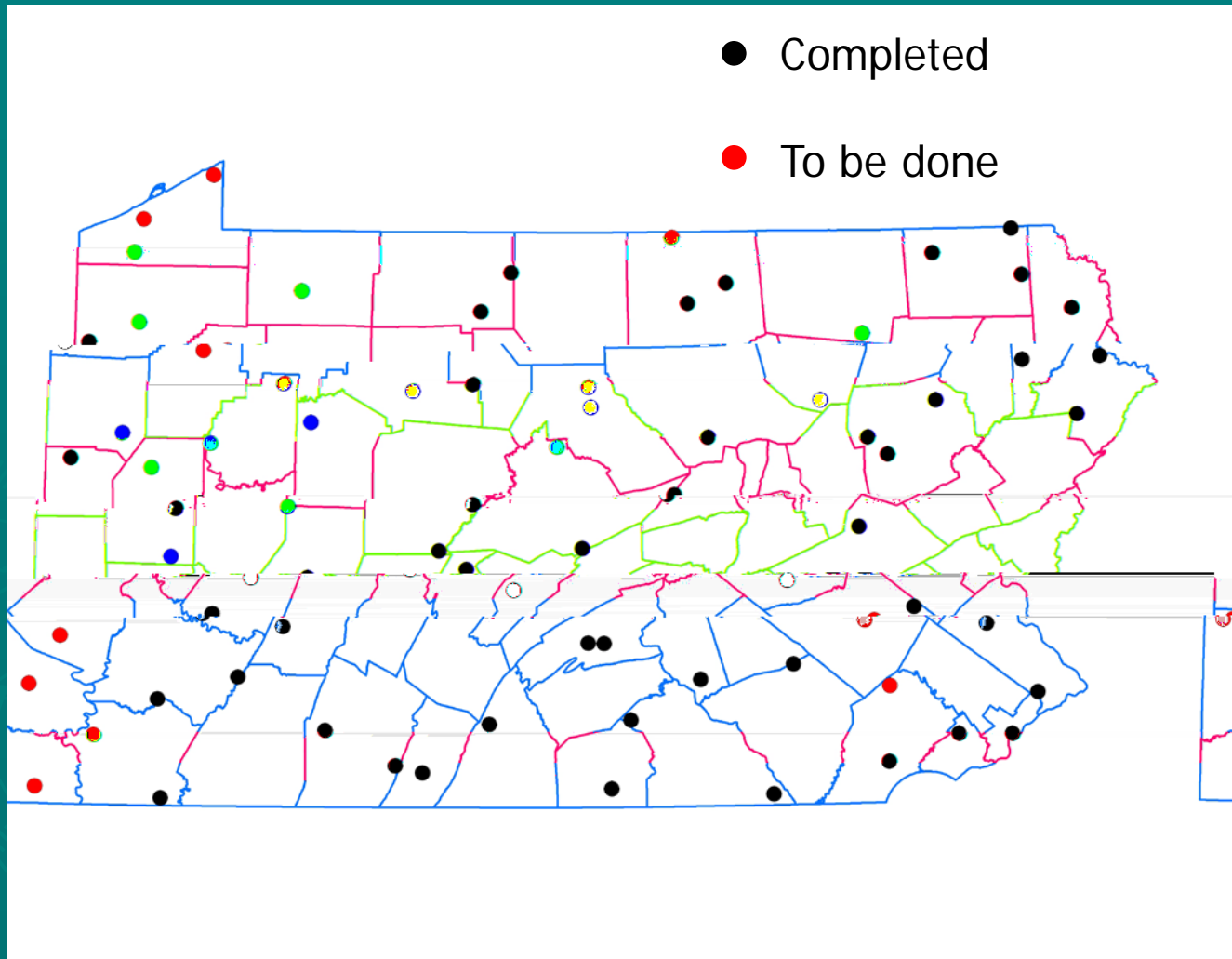Period: 1961-1990

6.7

0.94

USGS

Pilot Studies

EPA action level for residential use 400 ppm

Pilot Studies

Organochlorine pesticides

Pennsylvania

References

- http://minerals.cr.usgs.gov/projects/geochemical_landscapes/index.html

- Applied Geochemistry 24 (2009)